MATRIX ELEMENT PAVEMENT MARKER AND METHOD OF MAKING SAME

Field of the Invention

The present invention is directed to a pavement marker having an array of discrete pavement elements and a method for making the same, and more particularly, to an array of pavement elements arranged in a predefined pattern on a frangible and/or biodegradable carrier web.

Background of the Invention

Pavement marking sheet material that is economical to produce and performs well in both daylight and night conditions is a continuing goal of the pavement marking industry. Night performance is primarily provided by retroreflection, which may be defined as a phenomenon in which a large portion of incident light is returned in substantially the direction from which it originates. Spherical lens elements, typically tiny glass beads or microspheres in conjunction with reflective pigments, are well known for this purpose.

Flat single layer polymeric sheet material, as well as flat laminated materials, are known to hold retroreflective elements in position. The sheet material may be applied to a roadway surface and serves to both cushion and hold the retroreflective elements. The efficiency of flat pavement marking materials, however, is limited for two reasons. First, the array of retroreflective elements is directed upward, whereas the optimal orientation would be toward the vehicle headlights, which typically illuminate with retroreflective beads at an angle slightly above the

road surface. Second, in an upwardly directed fashion, the exposed surfaces of the retroreflective elements are exposed to maximum abrasive wear by vehicle tires, thus allowing for the rapid destruction of the exposed surfaces.

An alternative approach is to provide a raised pattern of retroreflective elements on a pavement marking strip. The raised pattern encourages the run-off of rainwater. Additionally, the raised pattern provides non-horizontal surfaces for supporting retroreflective elements. The non-horizontal surfaces tend to isolate and protect the optical surfaces from abrasive wear by traffic and provide a more efficient orientation for retroreflection.

Pavement marking tapes with retroreflective elements are disclosed in U.S. Patent Nos. 5,227,221, 4,988,555, and 4,988,541 (Hedblom). The preformed pavement marking tapes of Hedblom include a resilient polymeric backing sheet having a plurality of protrusions. A discontinuous layer of a liquid bead bond is applied to selected surfaces of the protrusions to retain microspheres at those locations. The relatively thick backing sheet adds cost to the pavement marking tape. Additionally, the resiliency of the backing sheet occasionally limits conformability to rough pavement surfaces.

U.S. Patent No. 4,792,259 (Eigenmann) discloses a method and apparatus for individually depositing discrete retroreflective markers onto a road surface. A backing sheet is pulled around a sharp angle so that the individual retroreflective markers are sequentially released and deposited onto the roadway surface. The feed rate of the backing sheet must be closely synchronized with the movement of the vehicle depositing the retroreflective markers in order

to maintain the proper spacing between the markers. It is also possible for the individual retroreflective markers to be overturned or displaced during tamping.

Brief Summary of the Invention

The present invention is directed to a pavement marker having an array of discrete pavement elements interconnected by a removable or frangible carrier web that is conformable and that minimizes unnecessary materials, improves tamping efficiency and isolates adjacent pavement elements. Various methods of making the array of pavement elements are also disclosed. The present invention is also directed to a method of applying the present array of pavement elements onto a pavement surface.

The present array of discrete pavement elements uses less material than conventional pavement marking tapes because the conformance layer between the raised discrete pavement elements is substantially eliminated. The tamping efficiency is also improved by isolating the tamping force on the pavement elements. In particular, the discrete pavement elements act as force-guides that direct the tamping forces to create an enhanced bond of marker material to the pavement surface. Once applied to the pavement, the array of discrete, pavement elements are not substantially interconnected, so that the delamination of a single pavement element does not adversely effect adjacent pavement elements.

In one embodiment, the method of making the pavement marker includes forming an array of pavement elements arranged in a predefined pattern interconnected by a carrier web. A frangible connection is formed between a plurality of the pavement elements and the carrier web. In one

embodiment, a pressure sensitive adhesive is applied to rear surfaces of the pavement elements. A release liner is applied over the adhesive. A frangible connection is formed between a plurality of the pavement elements and the carrier web, preferably without cutting through the release liner. After the array of pavement elements is applied to the pavement surface, the portion of the carrier web surrounding the pavement elements is removed, leaving an array of discrete, raised retroreflective pavement elements.

The pavement elements may be integrally formed with the carrier web as a unitary structure. Alternatively, the pavement elements may be bonded to the carrier web. The step of forming the frangible connection between the pavement elements and the carrier web can comprise partially severing the carrier web around a single pavement element or around groups of the pavement elements.

The present method may be used with various types of pavement markers such as retroreflective lenses, raised ridges with glass microspheres, retroreflective pavement elements, or single glass bead devices.

The carrier web may be a material that is frangible, biodegradable, and/or capable of deteriorating quickly from abrasion and impact from roadway traffic, such as paper, a liner, an open scrim, a screen, a mat, or a film or nonwoven web of a water-soluble or water-dispersible polymeric material. The carrier web is conformable, typically preferably extensible.

In an alternate embodiment, the pavement elements are formed in a predefined pattern on a carrier web. The carrier web has frangible portions between adjacent pavement elements that is preferably

capable of substantially deteriorating when exposed to roadway conditions for a short time. In one embodiment, a pressure sensitive adhesive is applied to the rear surfaces of the pavement elements and a release liner is applied over the adhesive. The carrier web serves to maintain the array of pavement elements in a predetermined configuration until they are applied to a pavement surface. The carrier web subsequently deteriorates, leaving an array of discrete pavement elements spaced in substantially the same configuration as on the carrier web.

In another embodiment, a carrier web is bonded to upper portions of an array of pavement elements. The carrier web being capable of maintaining the spatial orientation of the array of pavement elements during bonding of bottom surfaces of the pavement elements to a pavement surface.

In another embodiment, the pavement elements have a pressure sensitive adhesive on their bottom surfaces. The adhesive-coated bottom surfaces of the pavement elements are arranged in an array on a release liner. A carrier web is bonded to upper portions of the pavement elements to maintain the spatial orientation of the array when the release liner is removed. The carrier web may also be biodegradable, frangible and/or water soluble.

The present invention is also directed to a method of applying an array of pavement elements to a pavement surface. An adhesive, such as a pressure sensitive adhesive, is interposed between the pavement elements and the pavement surface. The portion of the carrier web surrounding the pavement elements is removed from the array. In another embodiment, the array of pavement elements are formed in a predetermined pattern on a conformable carrier web.

In another embodiment, the release liner is removed from the array of pavement elements. The pressure sensitive adhesive is engaged with the pavement surface under pressure. The portion of the carrier web surrounding the pavement elements is removed from the array.

The present invention is also directed to a pavement marking article. An array of pavement elements in a predefined pattern is interconnected by a carrier web. A frangible connection is located between a plurality of the pavement elements and the carrier web.

In another embodiment, a pressure sensitive adhesive is located on the rear surfaces of the pavement elements. A release liner extends over the adhesive. A plurality of slits are provided for at least partially severing the pavement elements from the carrier web without cutting through the release liner. The adhesive may either be pattern coated on the rear surfaces of the pavement elements or applied to substantially the entire rear surfaces of the pavement elements and the carrier web.

As used herein,

"Conformable" refers to a carrier web that exhibits a low unload energy of less than 125 grams/centimeter (0.7 pounds/inch) and an inelastic deformation of greater than about 10%, preferably greater than 20%, more preferably not less than 30% at 25°C

"Frangible connection" refers to a connection between the carrier web and pavement elements (or in some embodiments a segment of the carrier web between a minor portion of the carrier web attached to a single pavement element and the remaining portion of the

carrier web) that is easily broken or breakable after application of the pavement elements to the road.

"Frangible portion" refers to a portion of the carrier web that is easily broken or breakable, e.g., that is biodegradable, water-soluble, or otherwise capable of substantially deteriorating.

"Substantially deteriorating" refers to degradation and dissipation of the carrier web when exposed to a variety of environmental factors, such as abrasion, rain, ultraviolet radiation, and impact from roadway traffic, such that the carrier web cannot transfer energy sufficient to remove or delaminate a pavement element.

Brief Description of the Several Views of the Drawing

Figure 1 is a cross-sectional view of an illustrative array of pavement elements according to the present invention.

Figure 2 is a cross-sectional view of the array of pavement elements of Figure 1 being applied to a pavement surface.

Figure 3 is a cross-sectional view of an alternate illustrative array of pavement elements according to the present invention.

Figure 4 is a cross-sectional view of the array of pavement elements of Figure 3 being applied to a pavement surface.

Figure 5 is a cross-sectional view of an alternate illustrative array of pavement elements according to the present invention.

Figure 6 is a cross-sectional view of an alternate illustrative array of pavement elements having a top-mounted carrier web according to the present invention.

Figure 7 is a cross-sectional view of the array of pavement elements of Figure 6 being applied to a pavement surface.

Figure 8 is a schematic illustration of an exemplary process for making raise pavement elements according to the present invention.

Figure 9 is a schematic illustration of an alternate illustrative process for making pavement elements according to the present invention.

Figure 10 is a schematic illustration of an illustrative pavement marker according to the present invention.

These figures, which are idealized, are not to scale and are intended to be non-limiting.

Detailed Description of Illustrative Embodiments of the Invention

Figure 1 is a side sectional view of a pavement marker having an array 20 of pavement elements according to a first embodiment of the present invention. The array 20 includes a plurality of protrusions 24 and an integrally formed carrier web 22. In the illustrated embodiment, the protrusions 24 have side surfaces to which are bonded a plurality of retroreflective beads 36 using a binder that typically contains pigment flakes 32. The carrier web may be a polymeric film, paper, liner, screen, mat, nonwoven web, or open scrim that is removable, frangible, biodegradable, and/or capable of deteriorating quickly from abrasion and impact from roadway traffic.

An adhesive 34 is preferably pattern coated to bottom surfaces 36 of the protrusions 24 without being applied to the interstitial portions of web 22. The adhesive 34 may alternatively be coated across the entire surface of the carrier web 22 and the

protrusions 24. A release liner 38 optionally extends across the adhesive 34 until the array 20 is ready for use. Adhesives known to be suitable for adhering articles to pavement surfaces include pressure sensitive adhesives, hot melt adhesives, hot melt pressure sensitive adhesives, contact bond cement, thermoset adhesives and two-part epoxy adhesives. Some of these alternate adhesives are preferably interposed between the pavement elements and pavement surface (not shown) or are applied to the pavement surface before bonding, rather than being coated on the array of pavement elements.

A frangible connection 40 is formed around the perimeter of the protrusions 24, typically by die cutting, so that the carrier web 22 can be removed. The frangible connection 40 preferably has sufficient strength to releasably connect the protrusions 24 and carrier web 22 until the array 20 is applied to a pavement surface 42 (see Figure 2). The frangible connection 40 does not necessarily need to be around the immediate perimeter of the protrusions 24, but may be formed some distance from the perimeter of the protrusion 24. Forming the frangible connection 40 around a plurality of the protrusions or pavement elements refers to forming it generally around the perimeter of two or more discrete protrusions 24, or around groups of protrusions. Top surfaces 26 of the protrusions 24 may optionally include non-slip particles 30. The non-slip particles 30 are embedded in the protrusion 24. The non-slip particles 30 may be attached to the top surface 26 of the protrusion 24 by binder 32.

Figure 2 is a side sectional view of the array 20 of Figure 1 being applied to a pavement surface 42. The release liner 38 is removed and the

array 20 is tamped to the pavement surface 42. The protrusions 24 act as force-guides to focus the tamping forces directly to the interface between the adhesive 34 and the pavement surface 42. In an embodiment where the adhesive 34 is coated across the entire surface of the carrier web 22, the protrusions 24 minimize the tamping force applied to the carrier web 22.

The carrier web 22 that surrounds the pavement elements 44 is then removed or peeled-back from the array 20 by breaking the frangible connection 40. The adhesive 34 provides an adhesive force between the protrusions 24 and the pavement surface 42 greater than the breaking force of the frangible connection 40. The resulting array of discrete, pavement elements 44 is arranged on the pavement surface 42 in substantially the same configuration maintained by the carrier web 22 in the array 20. The discrete pavement elements 44 are not interconnected, so that the delamination of a single pavement element does not typically adversely affect adjacent pavement elements.

Figure 3 is a side sectional view of an alternate pavement marker having an array 50 of pavement elements 52 bonded to a carrier web 54 by any of a variety of suitable methods. An adhesive 56 is applied to the entire lower surface 57 of the carrier web 54 or underneath the pavement elements 52. A release liner 58 is optionally applied to the adhesive until the array 50 is ready for use.

Figure 4 is a side sectional view of the array 50 of Figure 3 applied to a pavement surface 42. The release liner 58 is removed and the array 50 is tamped to the pavement surface 42. The carrier web 54 defines frangible portions 60 between adjacent pavement elements 52. The frangible portions 60 are preferably capable of substantially deteriorating from the impact

of roadway traffic. As illustrated in Figure 4, the frangible portions 60 progressively deteriorates, leaving an array of discrete, pavement elements 52 having substantially the same pattern as on the carrier web 54 prior to application to the pavement surface 42. In an alternate embodiment, a series of slits 62 may optionally be formed around the perimeter of the pavement elements 52, as discussed above. The portions of the carrier web 54 surrounding the pavement elements may be peeled-back or otherwise removed, such as shown in Figure 2.

Figure 5 is an alternate pavement marker having an array 70 of pavement elements 72, 74 arranged on a carrier web 76. Pavement element 72 comprises a single bead 78 attached to a housing 80. Pavement elements 74 comprise an embedded cube corner retroreflective lens 82 bonded to the carrier web 76, e.g., by an adhesive 84. The carrier web 76 is coated with an adhesive 86 and optionally covered by a release liner 88 substantially as shown in Figure 3. The frangible portions 90 between the adjacent pavement elements 72, 74 may either be allowed to deteriorate from the impact of roadway traffic or can be severed around the perimeter 92 of the pavement elements 72, 74 for removal, as discussed in connection with Figure 2. In the embodiment of Figure 5, the carrier web 76 is preferably not biodegradable.

Figure 6 is a side sectional view of an alternate array 100 of pavement elements 102 having an adhesive 104 on a bottom surface 106. The bottom surfaces 106 are arranged in an array on a release liner 108. A carrier web 110 is bonded to portions of the pavement elements 102, preferably by an adhesive, to maintain the spatial orientation of the array 100 when the release liner 108 is removed. In one

embodiment, the adhesive used to bond the carrier web 110 to the pavement elements 102 has a lower peel strength than does adhesive 104 to the substrate (not shown). In another embodiment, the carrier web 110 is a biodegradable material, such as paper, or a water soluble or water dispersible polymeric film or nonwoven web.

Figure 7 is a side sectional view of the array 100 of Figure 6 bonded to a pavement surface 42. The release liner 108 has been removed and the array 100 has been tamped to the roadway surface 42. The carrier web 110 may then be removed, leaving an array of pavement elements 102 on the pavement surface. Alternatively, the carrier web 110 may be allowed to substantially deteriorate in place.

Figure 8 is a schematic illustration of one embodiment of an extrusion and embossing method 130 for manufacturing a pavement marker having an array of pavement elements 132 according to the present invention. The expression pavement elements refers to both finished pavement elements or protrusions that can be subsequently processed to form a pavement element, such as by application of reflective material. The elastomeric precursor sheeting 134 is embossed by an embossing roll 136 prior to vulcanization to form protrusions 144 of specified shapes and dimensions connected by a portion of the elastomeric sheeting 134 forming a base sheet 145. An adhesive 138 is applied by a coating roll 140. A liner 142 is applied to the layer of adhesive 138. Alternatively, the adhesive 138 and liner 142 can be simultaneously laminated to the rear surface of the embossed sheeting. The protrusions 144 formed on the embossed sheeting are then subjected to die cutting 146 to form a frangible connection 148 between the base sheet 145 and the protrusions 144.

The pavement elements 132 can be applied to a pavement surface generally as illustrated in Figures 1 and 2.

Exemplary materials for forming the precursor sheeting 134 include acrylonitrite-butadiene polymers, millable urethane polymers, and neoprenes. Extended resins, inorganic fillers, such as silica, and reinforcements may also be included. Pigment such as titanium dioxide are preferred in the base sheet to provide a white diffuse surface to uncoated portions of the base sheet 142 in the protrusions 138. Lead-free yellow pigments are may also be used. The present array of pavement elements may be made using a variety of techniques, such as disclosed in U.S. Patent Nos. 4,388,359, 4,086,388, and 4,988,541.

Figure 9 is a schematic illustration of a cast and cure method for making a pavement marker in accordance with the present invention. A polymeric material is extruded through a nozzle 150 from a screw-type extruder 152 to form a bank or tip of molten material 154 at an orifice between a steel forming drum 156 and a doctor drum 158. The circumferential surface of the drum 156 includes a series of cavities 160 which are the negative of the desired protrusions 162. The molten material 154 fills the cavities 160 and is solidified to form a series of protrusions 162 on an elastomeric web 168. The extruder 152 preferably meters the quantity of polymeric material. Alternatively, a skiving tool such as a roller or a doctor blade can be used to scrape excess polymeric material from the roller 156 before the assembly 166 is brought into engagement with the roller 156. The polymeric material is typically a thermoset polymer. The polymeric material may also include inorganic fillers and reinforcements, such as glass beads,

ceramic particles, micro-particles of glass or ceramic, and/or glass fiber strands.

Also entering the nip between the drums 156, 158 is an assembly 166 including a carrier web 168, an adhesive 170, and a release liner 172. Upon being drawn into the nip containing the molten material 154, the carrier web 168 fuses and becomes inseparably united with the protrusions 162. The forming drum 156 may optionally be heated to facilitate curing of thermoset materials or cooled to facilitate curing thermoplastic materials.

The array 174 of protrusions 162 is then subjected to die cutting 176 which at least partially severs the web 168 around the perimeter of the protrusions 162. In one embodiment, the die cutting step 176 cuts through the carrier web 168, but not through the adhesive 170 or the liner 172. The pavement elements may be subject to additional processing, such as the application of reflective material, either before or after the die cutting step.

In an alternate embodiment, the gap defined by the nip between the drums 156, 158 is increased so that the thin web of the thermoplastic elastomer composition is formed on the web 168 between the protrusions 162, such as is illustrated in Figures 1 and 2. The subsequent die cutting step 176 preferably severs the thin web and carrier web 168 around the perimeter of the protrusions 162. Alternate methods of forming structured protrusions onto a carrier web are disclosed in U.S. Patent Nos. 5,152,917 (Pieper et al.); 5,435,816 (Spurgeon et al.); and 5,500,273 (Holmes et al.).

In an alternate embodiment, a rotary screen hot-melt pattern coater is used to coat a pattern corresponding to the pavement elements. The

thermoplastic materials are first heated to a molten state and delivered to a die. The die coats the molten material not a screen with a specified pattern and places the materials onto a first surface of a web or frangible carrier having pressure sensitive adhesive and release liner on the second surface. The depth and definition of the pattern can be controlled by the die slot, speed of the belt, and/or viscosity of the thermoplastic material. The resulting assembly is then subjected to die cutting that at least partially severs the carrier web around the perimeter of the pavement elements. This embodiment of the present invention can be performed using a rotary screen hot-melt pattern coater available from May Coating Technologies, Inc. of White Bear Lake, Minnesota.

In yet another embodiment, insert molding in one possible injection molding technique may be used for forming the pavement marker in accordance with the present invention. The frangible carrier web can be inserted into the molds and the pavement elements can be molded on the top of the carrier web. Once the assembly is cooled, the pavement elements are ejected from the mold and the carrier web is indexed forward and the molding process repeated. Injection molding has the advantage that it is relatively fast and the technology is widely available. Other processing techniques applicable for making pavement elements according to the present invention are disclosed in U.S. Patent Nos. 5,201,916 (Berg et al.), 5,304,331 (Leonard et al.), and commonly assigned U.S. Patent application entitled Matrix Element Magnetic Pavement element and Method of Making Same (Attorney Docket No. 53750USA2A), filed on the same date herewith..

Figure 10 illustrates a raised pavement marker 210 having an exemplary array of pavement

elements 212 according to the present invention. The protrusions 214 typically have a height of about 0.38 millimeters to about 1.6 millimeters (0.015 - 0.065 inches). The carrier web 216 typically has a thickness of at least 0.025 millimeters (0.001 inches). The array 210 comprises rows and columns of protrusions 214 preferably spaced apart by a distance of about 1.6 millimeters to about 12.7 millimeters (0.063 - 0.5 inches), and more preferably spaced apart by about 3 millimeters to about 6 millimeters (0.125 - 0.25 inches). The spacing of the protrusions 214 in the array 210 will vary depending on the height of the protrusions and the particular application for which the pavement elements are to be used. In one embodiment, frangible connection 218 is formed around a group of the protrusions 214, rather than each of the discrete protrusions 214. Other spacing scenarios can be used, such as for long line applications disclosed in U.S. Patent No. 5,683,746 (Hedblom).

The pavement elements of the present invention may be coated with retroreflective beads by a variety of techniques, such as disclosed in U.S. Patent No. 4,988,541. Suitable bead bond material for adhering the beads may be either a thermoplastic or a thermoset polymeric binder. One such binder is vinyl based thermoplastic resin, including a white pigment, as described in U.S. Patent No. 4,117,192. Other suitable bead bond materials include two-part polyurethane formed by reacting polycaprolactone diols and triols with derivatives of hexamethylene diisocyanate; epoxy based resins as described in U.S. Patent No. 4,248,932, 3,436,359, and 3,580,887; and blocked polyurethane compositions as described in U.S. Patent No. 4,530,859. Other suitable bead bond materials are polyurethane compositions comprising a

moisture activated curing agent and a polyisocyanate prepolymer. The moisture activated curing agent is preferably an oxalolidene ring, such as described in U.S. Patent No. 4,381,388.

Particles such as retroreflective beads suitable for use in the process include glass beads formed of glass materials having indices of refraction (n) from about 1.5 to about 2.26, and more preferably from about 1.5 to about 1.9. As is well known in the art, glass beads of material having an index of refraction of about 1.5 are less costly and more scratch and chip resistant than glass beads of material having an index of refraction of from about 1.75 to about 2.26. However, the cheaper, more durable glass beads are less effective retroreflectors. In one embodiment, the glass beads may include a silver or other specular reflective metallic or dielectric coating. The non-embedded portion of the silver coat is subsequently removed to provide a highly effective retroreflector. In another embodiment, beads having a hemispheric coating of a specular reflective metal, such as silver, are applied to the liquid bead bond layer. Because the beads are randomly oriented when applied, a fraction of the beads become embedded in a orientation which is effective for retroreflection. Generally, the effectively oriented beads have the uncoated surface exposed and the silver coated surface embedded.

Preferred retroreflector beads are disclosed in U.S. Patent No. 4,564,556 and U.S. Patent No. 4,758,469. These beads are described generally as solid, transparent, non-vitreous, ceramic spheroids comprising at least one crystalline phase comprised of at least one metal oxide. These beads may also have an amorphous phase such as silica. The term non-vitreous

means that it is not been derived from a melt or mixture of raw materials brought to liquid state at high temperature, like glass. These spheroids are very resistant to scratching and chipping, being quite hard (e.g., above 700 Knoop) and can be made with a relatively high index of refraction (ranging between 1.4 and 2.6). Examples of the compositions of these beads are zirconia-alumina-silica and zirconia-silica.

The approximate weight of typical ceramic beads with a density of approximately 4.0 grams per cubic centimeter, corresponding to flood coatings (i.e., a monolayer of beads over all surfaces with binder 32) of the entire surface of the protrusion 24. Levels of bead application for selectively applied beads range from just greater than 0% to about 100% of flood coat. Preferred levels, however, are from 15-50% of flood coat, with about 30% being most preferred. Another consideration is the relationship of the bead bond layer to the bead size. Unlike flat pavement marking constructions, beads will retroreflect on the side surfaces of the protrusions when deeply embedded, as long as a portion of the bead surface is exposed. Preferably, beads should be embedded up to approximately 50 to 70% of their diameter in the liquid bead bond layer for an acceptable compromise between bead retention in the field and ability to retroreflect light. Retention of glass beads may also be improved by silane treatment.

Conformable Carrier Webs

Conformability of carrier web can be evaluated in several ways. One simple way is to press a layer or sheet of the material by hand against a complex, rough or textured surface, such as a concrete block or asphalt composite pavement, remove, and

observe the degree to which surface roughness and features are replicated in the layer or sheet. The conformable carrier web of this invention will conform to complex shapes and rough surfaces.

Elastic recovery is the tendency of a layer or sheet to return to its original shape after being deformed. Delayed elastic recovery can be observed by noting the tendency of the replicated roughness to disappear over time. A simple test for delayed elastic recovery is to use a blunt instrument to indent the carrier web. The ease with which an impression can be made and the permanence of the impression may be used to form rough comparative judgments about the conformance properties of the material used to form the sheet or layer.

Conformable carrier webs of this invention must be capable of being deformed under reasonable forces in order to take on the shape of the road surface irregularities and thereby to allow formation of a good bond to the road surface. By reasonable forces is meant that after application of the carrier web to a road surface and rolling over the applied, flat marking sheet with a suitable tamping means, the carrier web conforms to the road surface. In such an application, the tamped carrier web substantially replicates the surface texture of the road. The suitable tamping means should not be excessively unwieldy. For prior art preformed pavement marking tapes, a tamping cart with a load (total weight about 250 lbs. (115 kg)) has commonly been employed in the application of marking tapes.

Another test for conformability is available through the following sequence of steps: 1. A test strip about 2.54 centimeters (1 inch) wide and about 10.16 centimeters (4 inches) long is pulled (i.e.,

deformed or strained) in a tensile strength apparatus at a rate of about 30.5 centimeters/minute (12 inches/minute) until it is strained to about 105% of original sample length (elongation of about 0.51 centimeters). 2. The pull is reversed and the machine returned to its starting point at a rate of about 30.5 centimeters/minute, causing a complete release of the tensile stress in the sample. 3. The strain at which a resisting force is first observed on the second pull (i.e. when the sample again becomes taut) is observed. The strain at which resistance is first observed on the second pull, divided by the first strain is defined as inelastic deformation (ID). In the present embodiment, strain is measured as the distance until the sample is taut is divided by the original elongation of 0.51 centimeters. A perfectly elastic material would have 0% ID, i.e., it would return to its original length. Metals approach 90% ID, but yield only at very undesirably high tensile stresses. Preferably, the force required to achieve 5% strain (i.e., deformation) in a base sheet (initial thickness typically about 250 micrometers) is less than 25 lbs. per inch of sample width (44 Newtons/cm of sample width) and more preferably less than 10 lbs. per inch (18 NT per cm).

Unload energy is also a significant factor in determining the conformability of a carrier web for use in the present invention. The unload energy is defined as the energy remaining in the memory portion of an elongated material. Materials with lower unload energies should be more conformable.

Conformable composite materials of this invention combine a low unload energy of less than 1.25 grams/centimeter (0.7 pounds/inch) and an ID of greater than about 10%, preferably greater than 20%, more preferably not less than 30% at 25°C.

Patents and patent applications disclosed herein, including those disclosed in the background of the invention, are hereby incorporated by reference in their entirety. It will be apparent to those skilled in the art that many changes can be made in the embodiments without departing from the scope of the invention. Thus, the scope of the present invention should not be limited to the methods and structures described herein, but only to methods and structures described by the language of the claims and the equivalents thereof.

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